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Type of Organization: College or University

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Project Title: Plant-Based Extraction of Lead from Contaminated Sediment

Project Category: Contaminated Sediments

Rank by Organization (if applicable): 1

Total Funding Requested ($): 226,490 **Project Duration:** 2 Years

Abstract:

Milwaukee Harbor sediment dredged by the Army Corps of Engineers (COE) is placed in a confined disposal facility (CDF) which is reaching capacity. The Detroit District COE has been working with the Great Lakes National Program Office in on-going studies to bioremediate some dredged material in an effort to protect Lake Michigan from organic pollutants and reduce the cost of material disposal. However, high lead (Pb) concentrations are a concern in some locations. In addition, the City of Milwaukee is now coordinating major brownfield redevelopment plans in the Menomonee Valley adjacent to the CDF, and proven, low-cost remediation technologies are needed. Redevelopment and the demonstration project proposed will lead to appropriate management of contaminated industrial sites to protect the Great Lakes, will contribute to the greening of presently under-utilized urban space, will increase the tax base, and will create employment opportunities for disadvantaged urban residents. The purpose of the proposed work is to implement plant-based technologies (phytoextraction) to remediate Pb-affected CDF material. It is important that the demonstration project will stimulate the use of phytoremediation for Menomonee Valley remediation. Phytoextraction concentrates Pb within a volume of plant material that is significantly smaller than the volume of the affected dredge material or soil. In this way, Pb can be economically managed, and future dredge material can be placed in the reclaimed CDF volume.

A project team consisting of Marquette University (MU), University of Wisconsin-Milwaukee (UWM), U.S. Army Corps of Engineers (COE), Arcadis, Inc., and the City of Milwaukee has been assembled. MU, UWM, and Arcadis offices as well as Milwaukee City Hall are located within walking distance of the proposed site and the Menomonee Valley. Therefore, proposal team members are also members of the affected community.

Geographic Areas Affected by the Project

States:

- ☐ Illinois
- ☐ Indiana
- ☐ Michigan
- ☐ Minnesota
- ☐ New York
- ☐ Pennsylvania
- ☒ Wisconsin
- ☐ Ohio

Lakes:

- ☐ Superior
- ☐ Huron
- ☐ Michigan
- ☐ Erie
- ☐ Ontario
- ☐ All Lakes

Geographic Initiatives:

☐ Greater Chicago ☐ NE Ohio ☐ NW Indiana ☐ SE Michigan ☐ Lake St. Clair

Primary Affected Area of Concern: Milwaukee Estuary, WI

Other Affected Areas of Concern:

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

The Milwaukee River Basin Area of Concern (AOC) contains sediment and industrial sites with elevated concentrations of metals (e.g. lead) and organics (e.g. PAHs). Urban runoff and historical pollution have been identified by Marquette University researchers as significant sources of Milwaukee River Basin sediment contamination, with lead being the metal found at the highest concentration in urban runoff (Novotny et al., Wat. Sci. Tech., 28(8), 1993). Dredging of ship channels by the COE removes material which must be managed by placement in confined disposal facilities (CDFs) Unfortunately, many CDFs are nearly filled to capacity and management of dredge material is a looming problem. Methods to render CDF material suitable for beneficial uses are needed so that material may be removed so as to reclaim CDF space. It is envisioned that some or all CDFs can be transformed from facilities for permanent containment into more economical facilities for engineered maturing of material followed by removal. Studies conducted by the COE in association with GLNPO have begun to addressed organic contaminants. However, metals have not been addressed. In addition, redevelopment of the Menomonee Valley adjacent to the CDF is being planed by the City of Milwaukee (Reilly, B., Market Study and Plan for the Menomonee Valley, October, 1999). Some brownfields are candidates for phytoremediation. The urban environment would benefit from greening as well as remediation, but a local phytoremediation demonstration project is required to stimulate wide use of the technology.

Phytoextraction, the use of plants to remove metals and other constituents from earth material, is an appropriate sediment and brownfield management alternative to investigate. Basic implementation of the process for remediation of metals- and organics-contaminated sites has been accomplished (Carmen, E., From Lab to Landscape: Phyto-Enhanced Soil Bioremediation, Routledge Publishers, New York, NY, in press). In Wisconsin, proposing team members have employed phytoremediation for clean-up of fuel oil contamination (Carman et al., Journal of Soil Contamination, 7(4), 1998). Other proposing team members have extensive experience performing field-scale restoration of tallgrass environments (Reinartz, J. A., "Restoring Populations of Rare Plants," in The Tallgrass Restoration Handbook, Island Press, Washington, D.C., 1995) and genetic variation in plant species (Reinartz, J. A., "Comparison of Pollinator Flight Movements and Gene Dispersal Patterns in Mimulus ringens," Heredity, 75, 1995) as well as wetland plant ecology. Vegetative growth has already developed on the Milwaukee CDF. Therefore, the plants currently there or other plants will hyperaccumulate metals as they grow on the site. The lead-extracting ability of plants varies widely with species, rooting depth, soil characteristics, and extent of metal partitioning to the soil. Phytoextraction can be accomplished using high biomass-producing plants with or without soil amendment using nutrients or ligands. After approximately three months, plants are harvested and composed to reduce the volume for ultimate disposal. Estimates of annual Pb removal ranges from 2-17 kg/ha for a perennial wetland species harvested once a year, up to 500 kg/ha for a perennial southeastern grassland species harvested weekly.

Cost for plant-based metals removal has been estimated to be $6 per square yard for incorporation of amendments

approximately 2 feet deep (Dupont Corporate Remediation Group, 1996). A CDF site lends itself to a phytoextraction demonstration project in that material may be left within the CDF until clean-up goals are achieved. The following process will be employed:

1) Dredge material placement in the CDF in 1- foot lifts
2) Phytoextraction of material for one or more growing seasons
3) Harvesting of plant material and disposal described below
4) Removal of the upper 1-foot of dredge material to reclaim CDF volume

Existing CDF volume is then available for reuse since the volume of harvested plants will only be approximately 2% of the treated dredge material. Therefore, although harvested plant material must be properly handled, the costs are much lower than the costs associated with construction of new CDF volume. Harvested plant material containing >40 ppm of Pb can be ashed and the Pb reclaimed. Otherwise, the plants can be composted to reduce volume and then properly landfilled.

Proposed Work Outcome:

The outcome of the proposed work will be a new method for handling CDF dredge material affected by metals so as to reduce future dredge material disposal costs. In addition, the demonstrated process of phytoextraction for sediments could be applied to economically manage sediments from some hot spots within the Milwaukee Harbor and other locations in the Great Lakes region. A phytoremediation demonstration project at the Port of Milwaukee would also serve to stimulate other phytoremediation projects within the Menomonee River Valley and the surrounding urban community which is disproportionately affected by historical pollution. Phytoremediation may be appropriate for clean-up of many brownfield sites near the CDF. However, at this time more research and demonstration is required before these techniques can be widely employed. Some reviewers may argue that, if phytoremediation is appropriate, then let site owners pay for phytoremediation now. However, the technology has not yet been widely implemented; therefore, it is not currently a generally accepted field-scale technique. In regards to brownfields, in many instances potentially responsible parties no longer exist. A demonstration site is an important step towards using phytoremediation in the Menomonee River Valley which is a major venue for local, state, and federal urban redevelopment.

The proposed work consists of three phases to conduct an appropriate demonstration project and build upon prior phytoremediation efforts. Phase I will draw on the expertise of MU Water Quality Center environmental engineers and UWM Field Station plant biologists to compare the Pb-removing ability of at least four plant species to that of Indian mustard. During Phase II, bench-scale tests will be run using soil amendments for enhanced plant-based lead extraction, such as acetate and citrate, and results will be compared to parallel EDTA soil amendment results in terms of increasing Pb removal from CDF sediment and controllable Pb mobility in the soil-water system.

For the Phase I and II small-scale studies, dredge material will be collected from an area of the Milwaukee CDF called Borrow Area A. This area is a candidate for removal and was extensively sampled by the District during 1998. Samples had average Pb concentrations of approximately 300 mg/Kg in the upper five feet. Marquette University and University of Wisconsin-Milwaukee will perform laboratory, bench-scale investigations using plant-based lead extraction with and without both soil nutrient amendment and mild ligand amendments. Reporting will be a cooperative effort of MU and UWM. Each treatment will be replicated at least three times. Unplanted soil will also be evaluated for physical and biological differences due to mechanisms other than plant-based processes.

For the Phase III demonstration, a field-scale project will be carried out to assess actual Pb clean-up. A plot will be cleared within Borrow Area A, then MU and UWM will conduct the field study which will be designed based upon results of the small-scale Phase I and II studies.

MU and UWM will prepare Quality Assurance Project Plans (QAPPs). The Marquette University Water Quality Center laboratory is certified by the Wisconsin DNR for Pb and other analyses. Both MU and UWM will conduct the small-scale and field studies.

Project Milestones:	Dates:
Project Start	01/2001
Exchange Data/Define Roles/QAPP	04/2001
Initiate Small-Scale Studies	05/2001
Complete Small-Scale Studies	02/2002
Finalize Small-Scale Report	03/2002
Design Field Demonstration	04/2002
Field Demonstration	05/2002
Finalize Demonstration Report	01/2003

☒ Project Addresses Environmental Justice

If So, Description of How:

The proposed work addresses the Milwaukee Harbor Estuary AOC and the Menomonee River Valley. Within a 3.5 mile radius of both, 10 inner city neighborhoods are targeted by Community Development Block Grant (CDBG) programs. Many residents fish along the Milwaukee Harbor and are disproportionately affected by historical pollution in this industrial urban area. In particular, Milwaukee's growing Hmong population (originally from Laos), culturally rely on significant amounts of fish in their diet, fished from the river and lake, even with the ongoing fish consumption advisories. Adjacent valley neighborhoods are the most densely populated in the state, as well as the most under- and unemployed, relating to their designation as an EDA special impact area, a state development zone and a designated developable site under the Federal Enterprise Zone program. Increased central city economic opportunity is essential at a time when suburban industrial park development outpaces anything within the city. Outlying employers can not adequately attract workers while willing workforces are geographically isolated in urban neighborhoods. The proposed remediation can enable the needed urban development that can satisfy both the interests of employers and workers, while also yielding environmental benefits called for in southeast Wisconsin's metropolitan planning organization's long range plans.

☒ Project Addresses Education/Outreach

If So, Description of How:

The proposed tasks provide a unique opportunity for graduate students in Marquette University's Department of Civil and Environmental Engineering and in the University of Wisconsin Milwaukee's Department of Biology to work together on an interdisciplinary team addressing a problem in their own community. The proposed work will be the thesis topic for a graduate student Research Assistant at each institution.Results will be disseminated through Wisconsin DNR and City of Milwaukee officials, and a site tour will be scheduled during the end of Phase III.

In addition, the proposed demonstration project will stimulate the use of phytoremediation and green space creation in plans for the Menomonee Valley redevelopment and brownfields in Milwaukee, including a river-aligned Hank Aaron commuter bike trail, which recently was designated by the White House as Wisconsin's Millennium Legacy Trail. City planners intend to use the trail as a way to beautify the valley, while also demonstrating the remediative value of green plantings.

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	55,100	29,100
Fringe:	5,420	2,780
Travel:	0	0
Equipment:	0	0
Supplies:	14,300	0
Contracts:	118,000	12,000
Construction:	0	0
Other:	0	0
Total Direct Costs:	192,820	43,880
Indirect Costs:	33,670	0
Total:	226,490	43,880
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

The City of Milwaukee's Menomonee Valley Redevelopment Office will collaborate on the work proposed, and has received a USEPA Brownfields Assessment Pilot Demonstration Grant ($200,000) to look at area-wide soil and groundwater issues in the Menomonee Valley. The COE Detroit District is also a collaborator and has submitted an application to USEPA to enter into the Superfund Innovative Technology Evaluation (SITE) program. The SITE program would result in enhanced funding for evaluating innovative technologies at the CDF, including phytoremediation and bioremediation. The projects will be used to leverage work proposed herein.

Description of Collaboration/Community Based Support:

Partners in this program include the following:

Marquette University Water Quality Center
University of Wisconsin-Milwaukee Field Station
Army Corps of Engineers-Detroit District
Arcadis, Inc.
City of Milwaukee - Menomonee Valley Redevelopment Office

The project represents collaboration among universities, the Federal sector, the local government, and the private sector. The project team consists of the following:

Dr. Daniel Zitomer, Marquette University, Dept. of Civil and Environmental Engineering
Dr. James Reinartz, University of Wisconsin-Milwaukee, Dept. of Biological Sciences and Director, UWM field station
Mr. David Bowman, Army Corps of Engineers -Detroit District, Environmental Scientist
Mr. Eric Carman, P.G., Arcadis, Inc., phytoremediation specialist
Mr. Brian Reilly, City of Milwaukee - Menomonee Valley Redevelopment Coordinator